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# Forest Insect & Disease Management

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DETECTION SURVEY

## STUNTING OF FIRST-YEAR CONIFER SEEDLINGS IN LAKE STATES NURSERIES

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## INTRODUCTION

During 1977, a cooperative study between the Wisconsin Department of Natural Resources (DNR) and the Department of Plant Pathology, University of Wisconsin, Madison, established that stunting of 1-0 red pine seedlings in the seedbeds is one of the most serious problems currently confronting managers of Wisconsin's forest-tree nurseries. Growth of affected seedlings is arrested in June. Although a few primary leaves are produced, there is little or no elongation of shoots. The foliage acquires a purplish cast suggesting deficiency in phosphorus. A dormant terminal bud is formed during early summer. Normal growth usually resumes during the following growing season.

Contiguous seedlings in scattered short or long sectors of seedling rows are affected, while seedlings in immediately adjacent rows often develop normally. Consequences of stunting are (1) almost no growth of affected seedlings during the first year; (2) lack of uniformity, resulting in an increased cull rate in 2-0 and 3-0 beds; and (3) during drought years, high fall mortality of the stunted trees. Percentages of 1-0 red pine seedlings that remained stunted during 1977 at the Griffith (Wisconsin Rapids), Hayward (Hayward), and F. G. Wilson (Boscobel) DNR Nurseries in Wisconsin were 18, 13, and 23, respectively. During the 1976 drought year, more than 500,000 stunted 1-0 red pine seedlings (11% of the total production) died at Hayward Nursery.

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Seedling stunting in Wisconsin's nurseries could not be attributed to any fungus that could be isolated from the tops or roots of affected trees, or to a lack of ectomycorrhizae. Certain fungicidal seedbed sprays, particularly a mixture of benomyl and captan, significantly reduced the amount of seedling stunting at all three DNR nurseries in Wisconsin.

Similar stunting of seedlings was encountered recently at USDA Forest Service nurseries in the Lake States region, most notably at Toumey Nursery (Watersmeet, Michigan) and Eveleth Nursery, (Eveleth, Minnesota). Personnel of USDA Forest Service, State and Private Forestry, St. Paul, Minnesota, determined that over 30% of the 1-0 red pine seedlings were stunted in the most severely affected seedbeds at Toumey Nursery. At Eveleth Nursery, stunting was encountered both in 1-0 red pine and in 1-0 white spruce. Between 15 and 30% of the seedlings were stunted in some of the nursery seedbeds.

During October 1977, a cooperative project was initiated between the USDA Forest Service, State and Private Forestry, Forest Insect and Disease Management, St. Paul, Minnesota, and the Department of Plant Pathology of the University of Wisconsin, Madison. The objectives of the project were: (1) To determine whether any fungus not present in normal seedlings could be isolated from either the tops or roots of stunted seedlings; (2) To compare ectomycorrhizal development on the roots of normal and stunted seedlings; (3) To analyze foliage of normal and stunted seedlings for deficiencies or excesses of minerals; and (4) To compare the symptoms of stunted seedlings at Wilson, Griffith, Hayward, Toumey, and Eveleth Nurseries.

## MATERIALS AND METHODS

During October 1977, 300 normal and 300 stunted 1-0 seedlings of red pine and of white spruce were collected at Eveleth Nursery and at Hayward Nursery. In addition, 300 normal and 300 stunted 1-0 red pine seedlings were obtained from Toumey Nursery. Seedlings were stored at 4$^{o}$C in aluminum trays with the roots covered with nursery soil of their origin.

Seedling height was measured from the groundline to the tip of the terminal bud. Average seedling height was based on measurements to the nearest mm of 100 seedlings. Weight was determined to the nearest 0.01 g after drying separately the roots and tops of groups of 100 seedlings in a vacuum oven at 121$^{o}$C for 24 h. Average dry weights of shoots and roots were determined for calculating shoot-to-root ratios.

Two methods of quantifying ectomycorrhizae were used. In the first method,the top six lateral roots on 100 seedlings from each source and each category were examined with a 1.5X magnifier. A lateral root was classified as mycorrhizal if 75% or more of its short roots were mycorrhizal; otherwise, it was classified as nonmycorrhizal. In the second

method, samples were examined from the roots of 10 randomly selected seedlings of each lot. Lateral roots were excised from each seedling and placed end-to-end on a laboratory bench. At 10-cm intervals five 1-cm-long root samples were taken from each seedling. The numbers of mycorrhizal and nonmycorrhizal short roots on each 1-cm-long sample were then counted under a dissecting microscope (10X).

A total of 4,320 tissue transplants from stunted and nonstunted seedlings were made. Isolations of microorganisms from these seedlings were attempted on two media. Potato dextrose agar (PDA) was used as a nonselective medium, and Papavizas' (1967) modified peptone-PCNB medium was used as a selective medium for _Fusarium_. Half of the isolation attempts were made on each medium. Before isolation, seedlings were rinsed in water, washed with a wetting agent (Alconox), and rinsed in distilled water. All foliage was then removed and discarded. The remaining tissues were sterilized for 1 minute in 0.5% sodium hypochlorite and were rinsed in sterile distilled water.

From each seedling, microbial isolations were attempted from the terminal bud, the hypocotyl, the tap root, two sections of lateral roots, and a short root. Cultures were incubated at room temperature and examined at 4- to 6-day intervals. Subcultures of fungi isolated were kept for identification.

Foliage analyses were made by the University of Wisconsin Soil and Plant Analysis Laboratory, Madison. Two grams of foliage from each seedling lot was provided to allow determination of the level of N, P, K, Ca, Mg, Na, Al, Fe, B, Cu, Zn, and Mn.

## RESULTS

### Size of normal and stunted seedlings

Stunted seedlings produced much less height growth than normal seedlings and also weighed much less. The shoot-to-root ratios of the stunted seedlings were much lower than those for normal seedlings (Table 1). Stunted seedlings generally had well-developed root systems for their size, and root rot was not detected in any of the seedling lots.

### Mycorrhizal status of normal and stunted seedlings

Percentages of lateral roots classed as mycorrhizal ranged from 40 to 66 for normal seedlings and from 59 to 80 for stunted seedlings. Percentages of short roots that were mycorrhizal ranged from 36 to 75 for normal seedlings and from 54 to 74 for stunted seedlings (Table 2). No deficiency of mycorrhizal development was apparent on either species at any of the three nurseries (Table 2).

Microorganisms isolated from normal and stunted seedlings

Most of the common root-rot fungi of conifer seedlings, such as *Cylindrocladium* spp., *Pythium* spp., *Rhizoctonia solani*, and *Sclerotium bataticola*, were not detected. *Fusarium oxysporum* was isolated from 2 nonstunted red pine seedlings at Toumey nursery, and from 17 stunted red pine seedlings. There was no significant difference in the frequency of isolation of this fungus from either red pine or white spruce at the other nurseries. Other genera of fungi isolated but not considered significant were *Alternaria*, *Penicillium*, *Phoma*, *Robillardia*, and *Trichoderma*. These fungi were isolated as frequently from nonstunted as from stunted seedlings.

Foliar analysis

Levels of the minerals S, N, P, K, Ca, Mg, Na, B, and Cu in the foliage were within a normal range for all of the seedling samples tested (Table 3). Aluminum was excessively high (600 ppm) only in stunted white spruce seedlings at Eveleth Nursery and in stunted red pine seedlings at Toumey Nursery. Iron was higher than normal in stunted red pine seedlings from Eveleth Nursery and was excessively high in stunted red pine seedlings from Toumey Nursery. Although not correlated with seedling stunting, Zn levels were abnormally high in stunted white spruce seedlings from Hayward Nursery, in normal white spruce from Eveleth Nursery, and in stunted red pine seedlings from Toumey Nursery. Manganese levels were higher than normal in normal red pine and excessive in stunted red pine seedling from Toumey Nursery.

The stunting of red pine seedlings at Toumey Nursery, but not at the two other nurseries, could reasonably be attributed to excessive levels of Al, Fe, and Mn in the soil.

## CONCLUSIONS

1. Stunted seedlings generally were less than half the size of normal seedlings, both on a height and on a dry-weight basis.

2. Stunted seedlings had well-developed root systems for their size. Their roots showed no evidence of pathological deterioration. Shoot-to-root ratios were much lower for stunted than for normal seedlings.

3. Ectomycorrhizae were adequate both in stunted and normal seedlings; thus the stunting of seedlings could not be explained on the basis of a lack of ectomycorrhizae.

4. No deficiency of 13 different elements was detected in either normal or stunted seedlings.

5. Only <u>Fusarium oxysporum</u> was isolated more frequently from stunted than nonstunted seedlings and only from red pine at Toumey Nursery. Since it was not consistently isolated from all stunted seedlings, it is not considered the cause of stunting.

6. Stunting of 1-0 white spruce and 1-0 red pine seedlings seemed identical at Eveleth, Hayward, Griffith, and Wilson Nurseries; the cause of the stunting at these nurseries remains unknown.

7. The cause of stunting of 1-0 red pine seedlings during 1977 at Toumey Nursery appeared to be different from the cause at the other nurseries.

8. The stunting of 1-0 red pine at Toumey Nursery could reasonably be attributed to toxic levels of Al, Fe, and Mn. The high levels of these elements could be related to the fungicides used for control of foliar pathogens or to the pH of the soils in the affected beds, or both.

## RECOMMENDATIONS

1. Soil pH and fertility must be closely monitored. If the soils are too acidic (pH less than 5.0) or too basic (pH greater than 6.0), the availability of some micronutrients decreases severely. High pH also favors root-rot fungi.

2. Chemicals should be used prudently. Directions on labels must be followed. Excessive dosages can be hazardous to people as well as toxic to plants.

Table 1.--Average size and shoot-to-root ratios of stunted and normal 1-0 red pine and white spruce seedlings at Eveleth and Toumey Federal Nurseries and Hayward State Nursery

| | Height (cm) | | | | Dry weight (g) | | | | Shoot-to-root ratio | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | White spruce | | Red pine | | White spruce | | Red pine | | White spruce | | Red pine | |
| Nursery | Normal | Stunted | Normal | Stunted | Normal | Stunted | Normal | Stunted | Normal | Stunted | Normal | Stunted |
| Eveleth | 5.8 | 1.7 | 6.4 | 2.5 | 0.2 | 0.05 | 0.5 | 0.1 | 3.6 | 1.5 | 4.3 | 1.9 |
| Hayward | 3.5 | 1.4 | 5.6 | 3.8 | 0.1 | 0.02 | 0.2 | 0.1 | 2.4 | 1.8 | 4.1 | 3.0 |
| Toumey | -- | -- | 6.5 | 3.2 | -- | -- | 0.6 | 0.2 | -- | -- | 3.3 | 2.4 |

Table 2.--Mycorrhizal status of normal and stunted 1-0 white spruce and red pine seedlings at Eveleth and Toumey Federal Nurseries and Hayward State Nursery

| | Lateral roots with mycorrhizae[a] (%) | | | | Short roots mycorrhizal[b] (%) | | | |
|---|---|---|---|---|---|---|---|---|
| | White spruce | | Red pine | | White spruce | | Red pine | |
| Nursery | Normal | Stunted | Normal | Stunted | Normal | Stunted | Normal | Stunted |
| Eveleth | 63 | 67 | 40 | 80 | 73 | 62 | 56 | 74 |
| Hayward | 41 | 59 | 66 | 66 | 36 | 62 | 63 | 67 |
| Toumey | -- | -- | 51 | 62 | -- | -- | 75 | 73 |

a/ Based on examination of 100 trees; six lateral roots per tree.

b/ Based on examination of fifty 1-cm lateral-root sections.